BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

In the Matter of Application No. 96-1

Olympic Pipe Line Company

Cross Cascade Pipeline Project

PRE-FILED TESTIMONY OF JOHN R. MASTANDREA

ISSUE:
RISK ASSESSMENT

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What is your name and area of expertise?

My name is John R. Mastandrea. My main expertise is in the high technology areas of the environmental and aerospace fields for the past 35 years. Key technical areas where I have expertise include: tank and pipeline leak detection systems; risk analysis and spill prevention and control; site assessment, mitigation, and remediation; non-destructive testing; sensors, and instrumentation. My numerous risk assessment studies have included multi-modal assessments, i.e., comparing the risks of shipment by pipeline with the risks of shipment by other modes.

I have developed comprehensive preventative maintenance programs and standards for individual pipelines and nationwide for the United States Environmental Protection Agency (EPA). I developed tank and pipeline maintenance standards for the United States Navy. I developed an acoustic leak detection system now being used for ground testing for the Space Station Freedom at NASA's Huntsville facility.

I have extensive business experience in all aspects of tank and pipeline testing. I personally have used a large number of leak detection and other testing procedures for ascertaining the integrity of pipelines and tanks.

I have a Bachelor of Science and Masters of Science degrees in electrical engineering. I am a member of the American Society of Non-Destructive Testing and the Instrument Society of America. I hold five United States patents (and one Canadian patent) dealing with leak detection devices.

Did your work for the EPA include developing a model to predict the risk of spills from pipelines?

Yes. As an EPA consultant, in 1982 I developed a model to determine the risk of spills from petroleum pipelines. The model has been widely used since. Indeed, it is referenced in both Olympic's Revised Application and in EFSEC's Draft EIS.

What subjects will you address in your testimony?

First, I will explain the pipeline risk assessment model I developed for the EPA.

Second, I will discuss data that has become available since the model was developed which confirms the validity of the model.

Third, I will explain why it is essential to compute both the volume and frequency of expected spills in preparing an unbiased spill risk assessment.

Fourth, I will apply the model to Olympic's proposed pipeline and calculate the expected frequency and volume of spills from the pipeline.

Fifth, I will compare the predicted pipeline spill risk with the predicted spill risk from the so-called "No Action" alternative, that is, the existing system which relies on barging and trucks in addition to pipelines.

Sixth, I will explain why Olympic's risk assessment is in error and how those errors in every instance overstate the risks of spills from barges and trucks or understate the risks of spills from pipelines.

Seventh, I will provide calculations pertaining to the proposal's maximum spill size, minimum detectable leak, and leak rates as a function of various hole sizes.

Eighth, I will discuss various instances in which Olympic's Revised Application reveals that Olympic is not proposing to use state-of-the-art technology to avoid and detect leaks.

Ninth, I conclude with recommendations for improving this project if it were to go forward.

Would you please explain the risk assessment model you developed for the EPA?

Yes. The model provides a mechanism to calculate the expected frequency and volume of spills from any petroleum pipeline. The model and the research underlying the model are reported in a study entitled "Petroleum Pipe Line Leak Detection Study" (1982) prepared for the Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

I began by reviewing various databases which include spill reports detailing the frequency and volume of spills from petroleum pipelines. By reviewing this data, I was able to define a typical pipeline as being 25 years old and 10 inches in diameter used full time. My study refers to a one-mile stretch of this typical pipeline as the "reference pipeline." I was able to calculate that on average there are 1.3 spills per 1,000 miles of this reference pipeline. That converts to .0013 spills per year for a one-mile stretch of this typical pipeline. Expressed in scientific notation, this figure is 1.3×10^{-3} spills per mile per year.

Next, by reviewing the databases, I was able to determine which factors had the strongest influence on the frequency and volume of spills. Obviously, risks increases as the length of the pipeline increases. Similarly, risk decreases if use drops below 100 percent. The risk formula I developed involves "correcting" the 1.3×10^{-3} figure to account for the length and percentage of use of a given pipeline.

My review of the data revealed two other important correction factors. One involves the diameter of the pipe. Generally (in the relevant range), larger pipes (because they have thicker walls) have a lower spill incidence. Two, because of corrosion and other effects, the longer a pipe is in the ground, the higher the

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frequency of spills. Analyzing the data, I developed correction factors to account for both of these major influences on spill risk.

In summary, to calculate the expected frequency of spills from a given pipeline, you begin with the 1.3×10^{-3} spills/year for the reference pipeline and then adjust that as appropriate for the four correction factors (length, percentage use, diameter, and age). The result will be the expected number of spills per year for the given pipeline at a given age. If you want to determine the risk of a spill over the life of a pipeline, you must then repeat that calculation for each year (or series of years), modifying the age correction factor as appropriate.

Does your model predict the frequency of any size spill or only spills larger than some threshold?

As I have described to this point, the model only predicts spills larger than 50 barrels (2,100 gallons). That is because the databases I relied on primarily were limited to industry self-reporting which generally is limited to spills larger than 50 barrels.

However, by analyzing other data, I was able to develop an extrapolation which allows one to include in a risk assessment spills smaller than 2,100 gallons.

Are there instances in which it is important to include in the spill risk assessment spills smaller than 2,100 gallons?

Yes. There are several instances, but one is particularly applicable here. In this case, we are concerned not just with the risk of spill of the pipeline in the abstract, but also want to compare that risk with the spill risk associated with other competing transportation modes (trucks and barges). The spill data for trucks and barges are not limited by the 50 barrel (2,100 gallon) threshold applicable to the pipeline industry's reports. Consequently, when one develops a spill risk assessment for barges and trucks, the risk is typically the risk of a spill of any size or at least much smaller than the 2,100 gallon threshold in the pipeline industry database.

Using the same lower threshold on spill size is especially important because there are far more small spills than large spills. If you are looking at frequency of spills and on one side of the equation you have cut out many of the small spills (for instance, by using a 2,100 gallon lower threshold) and on the other side of the equation you have included these numerous small spills (by using no lower threshold or a very low threshold such as a half gallon), then you will produce a potentially very misleading comparison.

Indeed, Olympic committed this very error in undertaking its spill risk assessment. As I explain later, I have corrected this (and other errors) in my report.

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Incidentally, is there any terminology that we can use to distinguish between spills larger than and smaller than 2,100 gallons (50 barrels)?

Yes. The Draft EIS utilizes the term "rupture" to describe spills larger than 50 barrels and the term "leak" to describe spills smaller than 50 barrels. I have adopted that same terminology in my report and in this testimony.

Did your work for EPA also include a method for estimating the volume of spills and, if so, why?

It is critical that the volume of spills be computed in conjunction with computing the expected frequency of spills. If I tell you that a given transportation mode will likely cause 50 leaks in the next 50 years, you do not really know very much unless you know the size of those leaks. Fifty leaks of one gallon each might be considered almost trivial. Fifty leaks averaging tens of thousands of gallons each would merit a great deal of attention.

The importance of considering volume (along with frequency) is magnified when you are comparing risks between different modes of transportation. For instance, trucks are inherently limited to spilling no more than their capacity (roughly 10,500 gallons). In contrast, pipelines and barges can spill perhaps 100 times that amount.

Thus, it can be very misleading to look at frequency alone when comparing spill risks between different transportation modes. While trucks may spill more frequently than either pipelines or barges, the average spill size from a truck is less. Unless you factor in average spill size, you do not have a valid basis for making a comparison.

Did the work you did for EPA involve development of a method for predicting average spill sizes?

Yes. I used a process similar to the one I described earlier for developing an estimate of the frequency of spills. I utilized the same databases and determined the average spill size for the reference pipeline. That statistic is 1.3 barrels (54.6 gallons) of product spilled per mile per year. This can also be expressed as 1,300 barrels (54,600 gallons) spilled per 1,000 miles per year.

Again, I developed correction factors to account for differences between the subject pipeline and the reference pipeline. Several of the correction factors cover the same parameters (length, percentage use, and diameter). Several others are unique to calculating estimated spill volumes: pumping station shut-down time; mainline valve closure time; and line elevation.

Let us turn to the second topic of your testimony: The study you did for the EPA in 1982 necessarily utilized pre-1982 data. Have you had an opportunity to review post-1982 data to determine whether it is consistent or inconsistent with your model?

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Yes. I have reviewed several databases and reports for that purpose. In each instance, the values determined from these other databases and reports are remarkably comparable to the values in my 1982 study. This is detailed in my report (attached as Exhibit JRM-2) in § 2.1.2.

As one example, the California State Fire Marshall analyzed spill data in California and calculated a spill rate of 1.3×10^{-3} spills per mile per year for spills larger than 50 barrels for all pipelines. The California Fire Marshall's report was utilizing a database covering 1986-1989. This is the same value (1.3×10^{-3}) that I calculated utilizing the pre-1982 databases.

The California State Fire Marshall report also confirmed the correction factor I developed to include spills smaller than 50 barrels. The California State Fire Marshall calculates a spill probability for all leaks and ruptures (including those smaller than 50 barrels) of 7.08×10^{-3} per mile/year. When you apply my correction factor to include spills smaller than 50 barrels, the value produced by my formula is 7.15×10^{-3} spills/mile/year. These two numbers are very similar.

Let's turn to the third area of your testimony: calculating the spill risk for Olympic's proposed Cross Cascade Pipeline. What were the results of that effort?

Utilizing the Mastandrea/EPA formula I described above, I calculated the expected frequency and volume of spills from the proposed Cross Cascade Pipeline. Those values are listed in Table 3-1 of my report. I have included that table as JRM-3 to this testimony.

To summarize, the Cross Cascade Pipeline is projected to have 54 spills in the first 50 years of operation. The annual average amount of product spilled increases from 13,512 gallons in the first years to almost 30,000 gallons per year in the latter years (reflecting increased spill risks as the pipeline ages). The cumulative total estimate of product spilled over the first 50 years of the pipeline's life is 1,114,300 gallons.

How does this compare with other transportation modes?

The pipeline will result in a higher spill risk than if the existing transportation system were to continue.

What is your basis for that statement?

I calculated the spill risks associated with the existing system utilizing barges and trucks. The difference in risk is most vivid when you look at the total amount of product expected to be spilled in the next 50 years. As mentioned above, it is estimated that the pipeline would spill 1,114,300 gallons in its first 50 years of operation. In contrast, if the barges and trucks were to transport that same amount of product, they are expected to spill 210,987 gallons in that same 50 year period.

Could you express that in terms of a percentage?

Yes. The pipeline is expected to spill 500 percent more product than the existing system.

Does this mean that the pipeline is expected to spill more frequently than trucks and barges?

No. Actually looking at frequency alone, the pipeline would have fewer spills. But the pipeline's spills are on average far larger than the truck/barge spills. In other words, the pipe probably will have fewer spills, but those spills will be much larger and, in total, release far more product into the environment.

The higher spill frequency for the truck/barge system is because trucks have a higher frequency of spills than pipelines or barges. But looking at frequency alone is very misleading because those more frequent truck spills are, on average, far smaller in size.

Are you aware that Olympic's risk analysis concluded that "construction of the Cross Cascade Pipeline will reduce the risk of product spills?"

Yes.

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What accounts for the difference between your conclusion and Olympic's?

Several things. First, Olympic's conclusion is based exclusively on calculating the expected frequency of spills. The calculations entirely ignore volume. Olympic's analysis treats all spills -- no matter what their size -- as equal. According to Olympic, a two gallon spill from a tank truck has the same significance as a 50,000 gallon spill from the pipeline. Especially in this context where you are comparing risks between different modes of transportation, the failure to take into account volume in the calculations renders Olympic's analysis invalid on its face. Because pipeline spills on average are larger than spills from the barge/truck alternative, Olympic's failure to include spill volume calculations skews the analysis in favor of the pipeline.

Second, Olympic cut its analysis off after 20 years. As noted above, the spill risks associated with pipelines increase as the pipeline ages. Olympic's own analysis recognizes that the pipeline becomes riskier relative to trucks and barges as the years pass. For instance, Olympic calculates that the spill frequency for the pipeline will increase nearly two and a half fold between the fifth year and the twentieth year. <u>See</u> Olympic's Product Spill Analysis, Table 3-1 (Revised Application, Appendix B-2). At the same time, Olympic calculates that the frequency of spills from trucks and barges will increase by only roughly one-third to one-half (due to increases in volume shipped). <u>Id</u>. If Olympic had continued its analysis beyond 20 years, the increasingly risky nature of the pipeline would have had a substantial influence on Olympic's own analysis. Stated the other way, by terminating the analysis after just 20 years, Olympic has significantly understated the relative risks of the pipeline.

Is it reasonable to consider -- as Olympic did -- 20 years as the expected useful life of the proposed pipeline?

No. In my several decades of experience with the pipeline industry, I would say it is extremely rare (perhaps unheard of) to plan the construction of a major pipeline with plans to take it out of service after just 20 years. Similarly, spill risk assessments typically utilize a far longer range view as well. Olympic is planning to spend over $100 million in construction costs alone. (Revised Application at 2.3-2.) I cannot conceive that the pipeline would be decommissioned in just 20 years.

Were there other flaws in Olympic's analysis?

Yes, third, even in its limited analysis of frequency alone, Olympic made errors. For instance, in developing the frequency statistic for trucks, Olympic utilized a database which was not limited to trucks transporting crude oil and petroleum products. The database limited to petroleum trucks shows a far lower frequency of accidents. (This is consistent with expectations that petroleum truck drivers, carrying highly flammable loads, would on average drive more safely and perform heightened maintenance compared to the general trucking population.) When the petroleum trucks are segregated out of the more general database, an accident frequency is developed which is 4.77 times lower than that used in Olympic's risk analysis. By using the general truck database, Olympic overstated the expected frequency of petroleum truck accidents by a factor of 4.77.

Fourth, as previewed earlier, Olympic used different lower thresholds in calculating spill frequency. For pipelines, Olympic did not use the lower threshold volume correction factor, that is, they calculated the frequency of ruptures only (spills over 50 barrels (2,100 gallons)). But the truck spill database includes all spills, ruptures, and leaks. So Olympic is really comparing apples and oranges. Olympic is saying trucks have more ruptures and leaks than pipelines have ruptures alone. That is not a valid comparison.

If Olympic had corrected the pipeline frequency to include leaks down to a half barrel (21 gallons), the pipeline spill frequency would have increased by a factor of 4.

These two frequency adjustments are compound. That is, the 4.77 correction (to isolate petroleum trucks from general trucks) and the 4.0 correction to include pipeline leaks down to 21 gallons are multiplied to result in a 19.08 overall adjustment. In other words, these two factors alone resulted in Olympic overstating the frequency of truck spills relative to pipeline spills by a factor of 19.

A fifth major error results from Olympic's failure to consider the existing and future nature of barge traffic on the Columbia River. In calculating the frequency of spills from barges, Olympic utilized a worldwide tanker database of 40 incidents between 1974 and 1989, all exceeding 42,000 gallons. This leads to several errors.

One, there has been a sharp drop in spill incidents subsequent to passage of the Oil Pollution Act (OPA) in 1990. Utilizing a pre-1990 database overstates the barge risk.

Two, Olympic fails to account for the benefits of the barge fleet converting to double-hulls. Already, 65 percent of the product shipped on Tidewater's barges are in double-hulled vessels. By 2015, 100 percent will be in double-hulled vessels (as required by OPA 90).

The National Research Council recently released a study to determine whether OPA 90's mandate to double-hull marine vessels was having the expected beneficial effect on frequency and volume of spill. Based on its review of accidents involving the new double-hulled tankers, the National Research Council concluded that "the projected number of spills for doubled-hulled tankers is one-fourth to one-sixth of the number of spills projected for single-hulled tankers." <u>Double-Hull Tanker Legislation: An Assessment of the Oil Pollution Act of 1990</u>, National Research Council (1998). The study also documented that when a double hull does leak, it will typically leak less volume than a single hull. I am attaching a copy of excerpts of this report to this testimony as Exhibit JRM-4. Olympic's failure to account for this dramatic reduction in spills (frequency and volume) due to double-hulling yet again serves to overstate the barge risk.

The significance of this error is compounded by Olympic's failure to recognize that Tidewater's shipments in double-hulled barges will increase from 65 percent to 100 percent by 2015 (as required by OPA 90). Additional errors in Olympic's barge analysis are referenced in my report and detailed in the testimony of David Dickins.

When comparing the risks of the project versus risks of continuing use of the existing system, what assumptions did you make as to the impacts the pipeline would have on the amount of product moved by barge and truck?

I used the assumptions generated by Olympic. Olympic assumed that the pipeline would not have any impact on the amount of material coming in from other pipelines to eastern Washington (Yellowstone and Chevron) and that it would eliminate all of the truck and barge traffic taking refined products from western Washington to central and eastern Washington. I did not test the validity of these assumptions and simply incorporated them into my analysis.

There has been (will be) other testimony in this proceeding that, if the pipeline is built, truck traffic will not be reduced as much as Olympic claims. If that is true, how would that affect yours and Olympic's risk assessments?

If truck traffic does not decrease as much as Olympic asserts, the impact on Olympic's and my risk assessments would be similar. Olympic's analysis (and mine) is based on the assumption that the project would eliminate 60 truck trips per day. Remember that relatively speaking, trucks have more accidents than pipelines and barges. Olympic's assumption has placed all of those relatively high frequency truck accidents in the "no action" column and none of them in the "CCP" column.

If the assumption is incorrect and there is no reduction in truck traffic (it is merely rerouted) or if the reduction is less than 60 trips, then both Olympic's and my calculations regarding frequency of spills would have to be revised. For both analyses, the revisions would reduce or eliminate the frequency gap between the project and the "no action" alternative.

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What would that do to your overall conclusion that the pipeline is riskier than the current system?

It would make that conclusion even stronger.

Let's turn to your next issue. Would you please explain your calculation regarding the proposal's maximum spill size, minimum detectible leak, and leak rates as a function of various hole sizes?

Yes. First, I will explain my calculations regarding the proposed pipeline's maximum spill size. These calculations are detailed in my report in section 2.1.4. In calculating the maximum potential spill size, it is useful to think of a spill as consisting of four phases. First, the amount spilled before the leak is detected and confirmed. Second, the amount spilled after detection but before the pumps are shut down. Third, the amount spilled after the pumps are shut down but before the valves are closed (isolating the leaking line segment). Fourth, the amount which drains out after the valves are closed.

It turns out that one of the major variables is whether the valves are manually or remotely operated. An awful lot of product will escape a major break in the line in the time it takes someone to travel to possibly remote valve sites and close off the valves. The bottom line, if the valves can be remotely or automatically closed, the maximum spill from all four phases would be 607,651. If the valves require manual operation, this figure increases to 984,216.

What were your calculations regarding the leak volume that can go undetected?

This is detailed in my report in section 2.1.5.

First, it is important to recognize that the answer to this question varies depending on whether you analyze it assuming the use of the best available leak detection technology or if you answer utilizing the technology referenced in Olympic's Revised Application. Olympic has not committed in its Revised Application to utilizing the best available leak detection technology.

Second, it is useful to distinguish between the amount of product that can go undetected in the short term and that amount which can go undetected over longer periods of time. The short term leak detection systems proposed to be employed by Olympic are not as sensitive as those systems which are to be employed over longer time frames. (Neither Olympic's short-term nor long-term leak detection methods are as sensitive as the best available technology.)

Olympic claims that its short-term leak detection system is capable of detecting leaks of one percent of flow or smaller. Olympic has not presented documentation to support this claim. But if we accept the one percent figure, then it can be calculated that that system will not be able to detect reliably leaks smaller than 3,150 gallons per hour.

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This is a significant volume. Even a small, one or two gallon spill from a barge or truck is readily capable of detection. To put it in another light, to say that the pipeline cannot detect a spill smaller than 3,150 gallons per hour is like saying that we would not know that a nearly full tanker truck lost one-third of its load each and every hour and no one could detect it.

Over longer periods of time, the leak detection sensitivities of Olympic's system increase. Over a 24 hour period, Olympic's leak detection system might be able to detect leaks as small as 0.4 percent. But even at this increased sensitivity, that would mean more than 30,000 gallons could be lost each day without detection.

Over the period of a month or more, Olympic's leak detection capabilities might be as good as 0.2 percent. But that still means that the amount undetected per month could be as high as 453,600 gallons.

If Olympic were to use annual hydrostatic tests (Olympic is not proposing to do so once operations commence), Olympic could reduce the maximum annual undetected leak figure considerably, to 87,600 gallons.

Other leak detection systems with greater sensitivity also have been ignored by Olympic. For instance, hydrocarbon sensing cables can be laid parallel to the pipeline when it is constructed. These cables are capable of sensing the presence of hydrocarbon fumes in the soil at extremely low thresholds. The hydrocarbon sensing cable can detect virtually the first gallon of product which leaks from a pipeline and detect it within a matter of minutes or hours at most. These systems also have the advantage of being able to precisely locate the location of the leak.

What calculations did you perform to determine the leak rates of various hole sizes?

Those calculations are based on standard formulas. The results are included in my report in Table 2-9.

Let's move on to your next area of testimony. You stated you would discuss various instances in which Olympic's Revised Application reveals that Olympic is not proposing to use state-of-the-art technology to avoid and detect leaks.

Yes, that is true, and actually I have addressed some of these issues already. For instance, I just explained that Olympic is not utilizing state-of-the-art leak detection technology. Both annual hydrostatic tests and hydrocarbon sensing cables are far more sensitive than the leak detection systems incorporated in Olympic's proposal.

Olympic is proposing to utilize a system known as "SCADA subsystem" to determine leaks in the short term. (SCADA stands for Supervisory Control and Data Acquisition.) Basically, this is the system that monitors pressure and other pipeline parameters (the SCADA system) supplemented with a computer subsystem which looks for anomalies in the pressure and other readings. Not only is this type of system not state-of-the-art, but it is not possible to determine from Olympic's Revised Application whether Olympic is even using one of the better SCADA subsystems on the market. The sensitivities of SCADA subsystems varies considerably. Olympic has not provided information sufficient to allow verification of the sensitivity of the particular SCADA subsystem Olympic proposes to use.

Another example of Olympic not utilizing state-of-the-art technology is its failure to use double-walled pipes. Double-walling serves several purposes. One, it provides additional protection for the inner pipe which carries the product. Second, the outer pipe provides a containment space if the inner pipe leaks. Third, highly sensitive leak detection systems can be placed within the void space between the inner and outer pipe. Olympic does not propose to use double-wall pipe anywhere along its 231 mile route, not even in the most environmentally sensitive or highly populated areas.

Another example relates to the use of an internal inspection device (known in the industry as a "smart pig"). Like the SCADA subsystems, there are many different types of smart pigs with highly variable abilities to detect deformities on the inside of the pipe. Olympic has not stated what type of "smart pig" it proposes to use and therefore it is impossible to determine that Olympic is proposing to use a state-of-the-art smart pig system. Further, Olympic is committing to run the smart pig down the pipe only once every five years. A shorter interval between tests (e.g., every three years) would substantially reduce the risk of undetected deformities causing spills.

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Finally, let's turn to your last area of testimony, that is, your recommendations for improving this project if it were to go forward.

I am gladly you qualified the question with the phrase "if it were to go forward." Based on the risk assessment in my report, I could not recommend that this project go forward; it appears to create more risks than the current system.

But if it were to go forward, there is a long list of improvements that could be made. Several of them I have already referenced in this testimony including: using doubled-walled pipes; using hydrocarbon sensing cables; requiring hydrostatic tests annually; requiring state-of-the-art SCADA subsystem; and requiring state-of-the art "smart pig" used at least every other year. Additional recommendations are included in my report in Section IV.

END OF DIRECT TESTIMONY OF WITNESS

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